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Implementation of Lean Six Sigma in Improving Quality by Reducing Defective Products in Aqua Mineral Water Gallon Distribution

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ABSTRACT

Surya Galon Agent is one of the gallon agents in Sidoarjo. The gallon product that is in great demand is the AQUA gallon. The problem faced is the high number of defects. This research aims to identify the types of defects that cause high levels of weekly defects for one year, determine the factors that influence the quality of AQUA mineral water gallon products at Galon Surya Agent, analyze the main causes of each type of defect and provide suggestions for improvement using the Lean Six Sigma approach. The Lean Six Sigma method seeks to integrate Lean manufacturing principles with Six Sigma. From the total number of gallons of AQUA mineral water products totaling 5720 units, the number of damaged units was 220 units. From research that has been calculated, the DPMO result is 1282 with a sigma level of 3.73. These results show that quality control for AQUA gallon mineral water products still requires improvement to minimize the number of defects. Analysis of SQCDMPE (Safety, Quality, Cost, Delivery, Moral, Productivity, Environment) is Improved monitoring of raw materials; Reduction in defect rate from 3.73 sigma to 4.01 sigma, an increase of 0.28 sigma; Decrease in repair costs through quality control; Improvement in timely delivery of products to consumers, reducing customer complaints; Increased employee satisfaction and motivation through training programs and rewards; Increased productivity due to process improvements and more regular machine maintenance; Reduction in environmental impact through better waste management and use of more eco-friendly raw materials.

Keywords: Defect, DMAIC, lean six sigma, mineral water

Introduction

Along with the advancement of Science and Technology that is becoming increasingly sophisticated, it greatly influences economic behavior, impacting competition within companies, both in the service and manufacturing sectors (Anh et al., 2023). Competition not only occurs at the company and human resource levels but also encompasses the quality of the products produced (Surange, 2015). Product quality is the main parameter in determining customer satisfaction with the products they purchase and use (Rochmoeljati et al., 2022). High-quality products can meet customers' expectations and needs, which in turn drives companies to continuously maintain product quality to stay competitive with other companies and keep customer satisfaction (Nugraha, 2022; Duc & Thu, 2022).

Bottled Drinking Water has now been widely accepted by the public, in line with their desire to obtain drinking water that is processed and packaged hygienically and safely, and meets AMDK quality standards. Surya Agent is one of the small agents that is generally easily accessible to the public or local community. One of the products sold is mineral water gallon products, where this

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product has the highest sales. Mineral water gallon products at Surya Agent also experience defects and numerous complaints from customers.

One method to control quality is by using the Six Sigma approach. Six Sigma is a vision to improve quality by achieving a target of 3.4 Defects Per Million Opportunities (DPMO) in every product transaction (both products and services) and is an intensive effort towards defect-free perfection (Fithri, 2019). The Six Sigma method is also considered an approach to control and improve the quality of the production process by focusing on corrective actions (Arier et al., 2024). This research applies the five-step model in Six Sigma DMAIC, namely define, measure, analyze, improve, and control. This model combines various statistical tools to improve quality and reduce the percentage of defective products produced in mineral water gallon products.

Material and Methods

This research was conducted at Surya Gallon Agent, a business that provides AQUA mineral water gallons to meet consumer needs. The data analyzed is the recapitulation data of AQUA mineral water gallon arrivals over the period from January to June 2022, totaling 24 weeks. In this study, primary data was collected through interviews and direct observation at Surya Gallon Agent. Meanwhile, secondary data was obtained from reports or historical data that have been archived and documented by Surya Gallon Agent. The data processing method in this study uses the Lean Six Sigma method. The data processing technique for the Lean Six Sigma method uses quality control tools, namely the 5S Method (Seiri, Seiton, Seiso, Seiketsu, and Shitsuke). Data analysis was carried out using the Lean Six Sigma methodology with 4 DMAIC phases (Define, Measure, Analyze, Improve, and Control). The research steps can be described as follows:

1. Define
   In the define phase, the research directly observes the company's situation, starting from the production process that includes raw material preparation to product delivery, and also evaluates the employees' work in the company.
2. Measure
   In the measurement phase, potential CTQ (Critical To Quality) is determined. Then the production process capacity is evaluated using a u control chart to determine the process capacity value. Additionally, the sigma level of the production process is calculated.
3. Analyze
   In this phase, attention is focused on the types of failures that always appear in the product results. The aim is to identify the main causes and root problems of product defects using analysis tools such as cause-and-effect diagrams and the 5 Whys method.
4. Improve
   Improve is the improvement phase aimed at achieving a certain sigma level by developing improvement proposals tailored to the root causes of each type of failure.
5. Control
   The control phase is the final stage in the implementation of Six Sigma to improve quality. It involves documenting and disseminating the results of quality improvements, as well as using best practices from successful process improvements as standards.

Results and Discussion

Define

The define phase begins with identifying the failure rate in the mineral water gallon production process. At this step, the proportion of defects that are the primary cause of damage, which represents the root problem in the product, is determined. Based on historical data from the past year, the average defect rate before the study was 7.04%.

Another tool used to identify problems is Critical to Quality (CTQ), which refers to features measured from the product to ensure it meets specifications that satisfy customer expectations. CTQ aims to identify defect attributes in assessing product quality.

Table 1. Identification of Defects for January-June 2022

No	Type of Defect	Quantity (Units)	Percentage (%)
1	Damaged Caps	131	32,5
2	Cloudy Water	137	33,5
3	Dirty Gallons	135	34
	Total	403	100,0

Table 2. Critical to quality

CTQ	Criteria	Description
CTQ-1	Damaged Caps	Damaged or torn gallon caps are not only unsightly but can also cause the product packaging to open, allowing dirt or dust to enter the product packaging.
CTQ-2	Cloudy Water	Cloudy water in gallon packaging renders the mineral water unfit for consumption, as it may contain impurities or bacteria that could be harmful if ingested.
CTQ-3	Dirty Gallons	Dirty gallon packaging can lead to contamination of the product with external bacteria. The product's quality is compromised due to the presence of dirt on the packaging.

Measure

After identification, corrective actions must be taken promptly because CTQ is an attribute that impacts product quality. Next, process capability (sigma) and DPMO are calculated. Measuring sigma capability aims to assess the process's ability to produce products that have been identified with defects.

Table 3. Sigma Level Before Improvement

Week	DPU	DPO	DPMO	Sigma Level
Jan-1	0,0594	0,019802	19802	3,56
Jan-2	0,0370	0,012346	12346	3,75
Jan-3	0,0189	0,006289	6289	4,00
Jan-4	0,0566	0,018868	18868	3,58
Feb-1	0,0370	0,012346	12346	3,75
Feb-2	0,0196	0,006536	6536	3,98
Feb-3	0,0485	0,016181	16181	3,64
Feb-4	0,0424	0,014124	14124	3,69
Mar-1	0,0167	0,005556	5556	4,04
Mar-2	0,0351	0,011696	11696	3,77
Mar-3	0,0508	0,016949	16949	3,62
Mar-4	0,0175	0,005848	5848	4,02
Apr-1	0,0550	0,018349	18349	3,59
Apr-2	0,0522	0,017391	17391	3,61
Apr-3	0,0417	0,013889	13889	3,70
Apr-4	0,0256	0,008547	8547	3,88
Mei-1	0,0265	0,008850	8850	3,87
Mei-2	0,0561	0,018692	18692	3,58
Mei-3	0,0545	0,018182	18182	3,59
Mei-4	0,0513	0,017094	17094	3,62
Jun-1	0,0427	0,014245	14245	3,69
Jun-2	0,0455	0,015152	15152	3,67

To be continued...

Jun-3	0,0566	0,018868	18868	3,58
Jun-4	0,0288	0,009615	9615	3,84
Total	0,0389	0,012963	12963	3,73

Based on the defect rate calculations, the overall DPMO is 1282 and the sigma value is 3.73. These results indicate that quality control for gallon mineral water products still requires improvement to further reduce defect rates.

Analyze

In the analysis phase, root cause analysis of defects occurring in the mineral water gallon distribution process is conducted. This step begins with the creation of a Pareto chart to help researchers focus more on analyzing issues based on their priority. The Pareto chart can be seen in Figure 1.

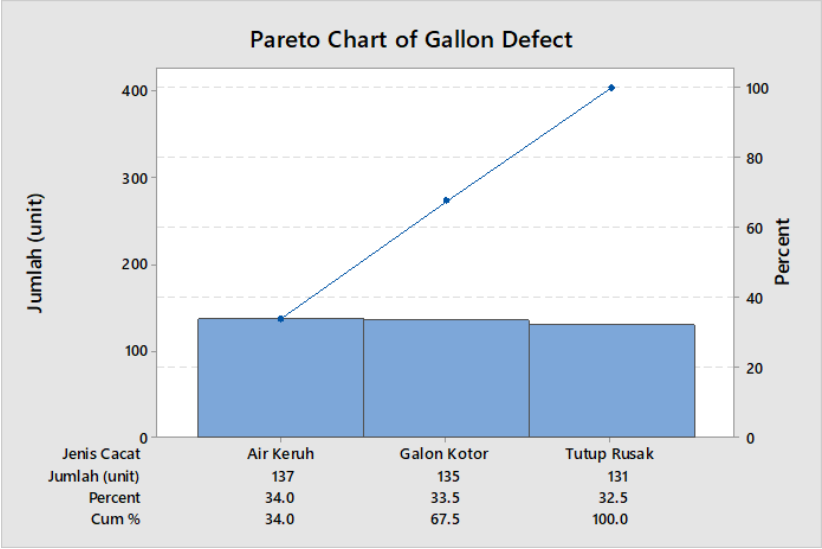

Figure 1. Pareto chart

Based on the Pareto diagram, improvements will be prioritized for defects, starting with cloudy water at 34%, followed by dirty gallon products at 33.5%, and damaged caps at 32.5%. By understanding the sequence of defects, both the author and the company can plan corrective actions to reduce defects. Next, a fishbone diagram will be created to identify the root causes of the defects considering various factors. The fishbone diagrams can be seen in Figures 2 through 4.

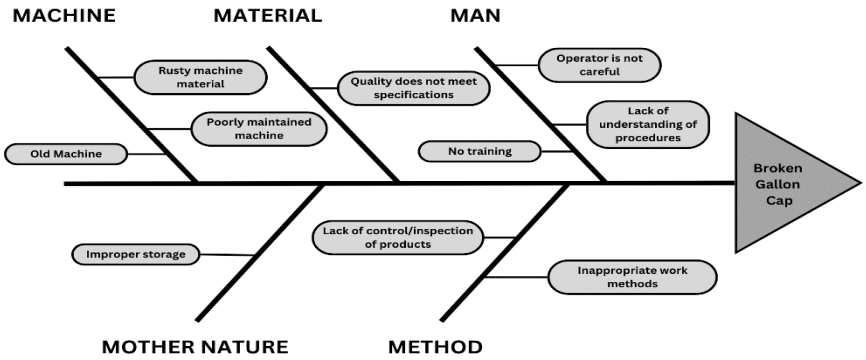

Figure 2. CTQ-1 Fishbone defect

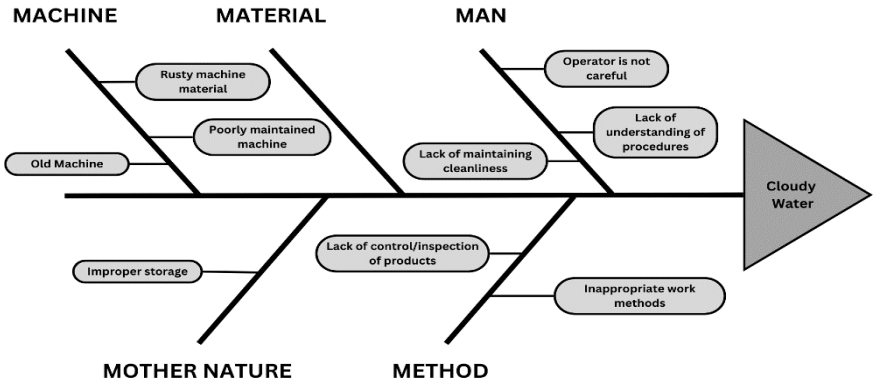

Figure 3. CTQ-2 fishbone defect

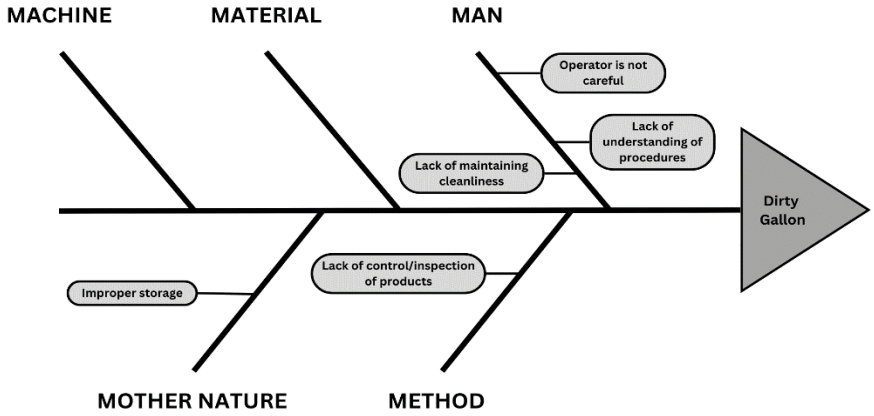

Figure 4. CTQ-3 fishbone defect

Improve

The goal of this stage is to address quality issues arising in the distribution process by implementing the 5S method. The 5S method, which includes Seiri, Seiton, Seiso, Seiketsu, and Shitsuke, is a method for organizing and maintaining the work environment through intensive efforts in manufacturing industries. The analysis of the mineral water gallon distribution process using the 5S method can be seen in Table 4.

Table 4. 5S method

5S	Actions
Seiri (Sort)	• Separate cartons for use in the warehouse. • Finished product cartons are moved to the warehouse.
Seiton (Set in Order)	• Label identification for easy recognition in the production area. • Finished products are organized in the warehouse according to arrival sequence.
Seiso (Shine)	• Employees are required to wash their hands at the provided sink. • Brooms, mops, and cloths are provided around the work area.
Seiketsu (Standardize)	• Habitual practice for employees to work neatly, return tools to their places, and maintain personal cleanliness. • Daily routine monitoring is conducted to take further action if any disruptions are found in the distribution process.
Shitsuke (Sustain)	• Regularly set specific targets between divisions to boost morale and development. • Outstanding employees are recognized periodically.

Control

The purpose of this control phase is to evaluate the performance achieved during the improvement phase. After addressing the issues, monitoring was conducted on the defect results for the period of July to December 2022. The defect identification data for the subsequent period is shown in Table 5.

Table 5. Defect identification for the period of July-December 2022

No	Type of Defect	Quantity (Units)	Percentage (%)
1	Damaged Caps	25	49,02
2	Cloudy Water	12	23,53
3	Dirty Gallons	14	27,45
	Total	51	100,0

Based on the improvement data, there is a significant decrease in the average defect rate from 7.04% to 1.79% compared to the previous period. However, there may still be defects due to other unknown factors or ongoing issues with the improvement process.

Table 6. Sigma level after improvement

Week	DPU	DPO	DPMO	Sigma Level
Jul-1	0,0084	0,002801	2801	4,27
Jul-2	0,0094	0,003145	3145	4,23
Jul-3	0,0089	0,002976	2976	4,25
Jul-4	0,0194	0,006472	6472	3,99
Agu-1	0,0288	0,009615	9615	3,84
Agu-2	0,0086	0,002874	2874	4,26
Agu-3	0,0175	0,005848	5848	4,02
Agu-4	0,0167	0,005556	5556	4,04
Sept-1	0,0095	0,003175	3175	4,23
Sept-2	0,0259	0,008621	8621	3,88
Sept-3	0,0254	0,008475	8475	3,89
Sept-4	0,0288	0,009615	9615	3,84
Okt-1	0,0085	0,002849	2849	4,26
Okt-2	0,0094	0,003145	3145	4,23
Okt-3	0,0300	0,010000	10000	3,83
Okt-4	0,0273	0,009091	9091	3,86
Nov-1	0,0270	0,009009	9009	3,87
Nov-2	0,0300	0,010000	10000	3,83
Nov-3	0,0088	0,002924	2924	4,26
Nov-4	0,0083	0,002778	2778	4,27

Based on the results after the improvement, the sigma level increased from 3.73 to 4.01, showing a rise of 0.28. The Sigma Level is now in a good category, but ongoing quality control and monitoring are needed for other aspects of quality management.

Analysis of SQCDMPE (Safety, quality, cost, delivery, moral, productivity, environment)

The achievement of improvement targets has been proven, and the enhancement in quality is also reflected in all aspects of SQCDMPE (Safety, Quality, Cost, Delivery, Moral, Productivity, Environment) as shown in Table 7.

Table 7. SQCDMPE analysis

No	Parameter	Results After Improvement
1	Safety	Improved monitoring of raw materials.
2	Quality	Reduction in defect rate from 3.73 sigma to 4.01 sigma, an increase of 0.28 sigma.
3	Cost	Decrease in repair costs through quality control.
4	Delivery	Improvement in timely delivery of products to consumers, reducing customer complaints.
5	Moral	Increased employee satisfaction and motivation through training programs and rewards.
6	Productivity	Increased productivity due to process improvements and more regular machine maintenance.
7	Environment	Reduction in environmental impact through better waste management and use of more eco-friendly raw materials.

Conclusion

This study is designed to analyze and determine quality improvements for AQUA mineral water gallons at Surya Gallon Agent. In gallon production, a sigma capability of 3.73 was found with an overall defect rate of 1282 defects per million. The factors causing defects include insufficient raw material inspection, poor machine maintenance, inadequately designed work methods, lack of operator precision, and improper storage. From the Six Sigma analysis, the three highest defects identified were dirty gallons (34%), cloudy water (33.5%), and damaged gallon caps (32.5%). The suggestions provided in this study to reduce defective products include establishing material quality standards, conducting regular machine maintenance, enhancing employee performance supervision, giving directions before starting activities, and improving the storage warehouse.

The results of applying product quality control showed a significant reduction in the average defect rate from 7.04% to 1.79% and an increase in the sigma level from 3.73 to 4.01. Although the sigma level is already in a good category, continuous quality control and monitoring efforts are necessary to maintain quality.

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